

# Candidate Features for Quality Assessment

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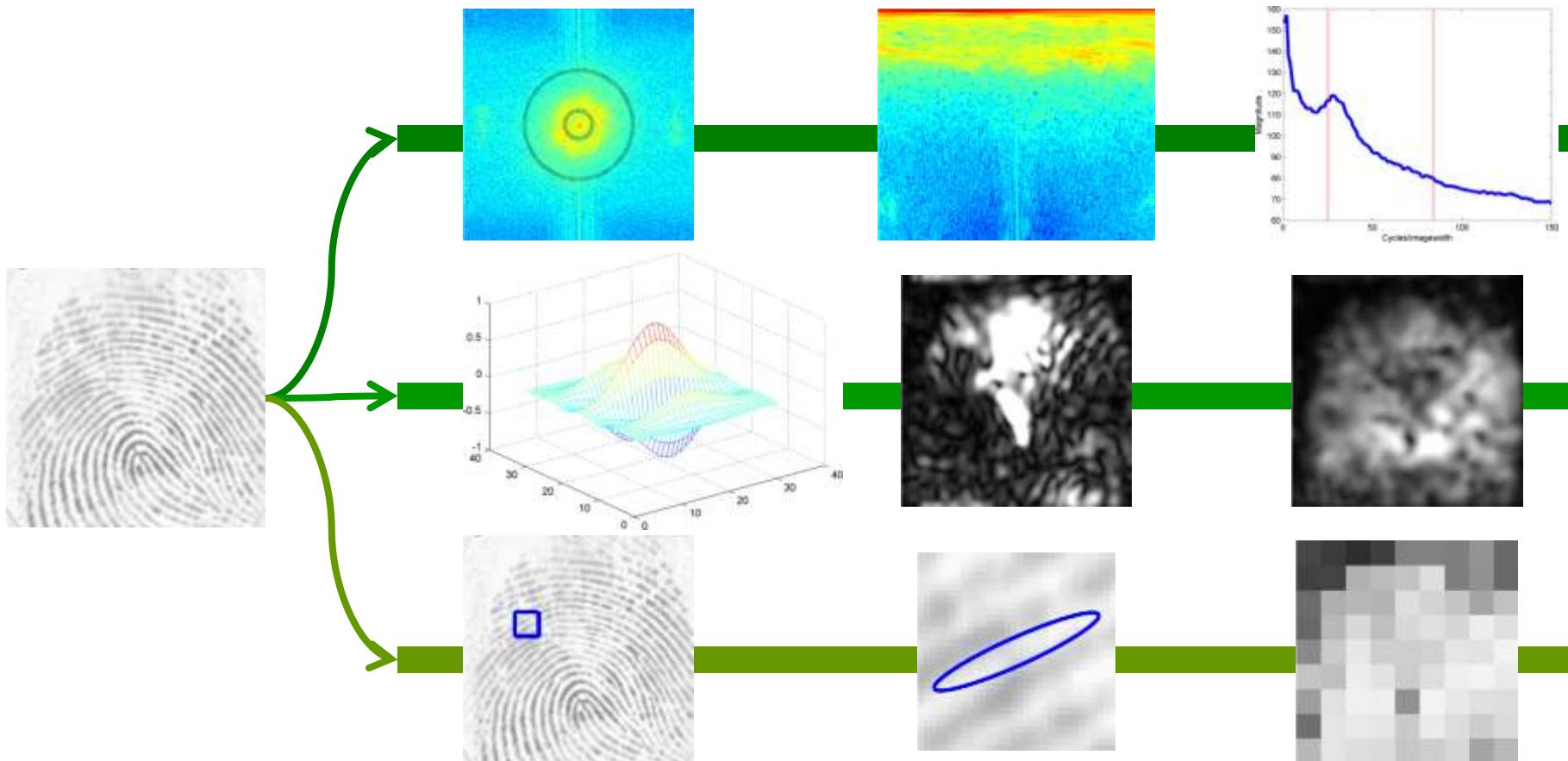


Bundeskriminalamt



# Quality Features For NFIQ 2.0

- Requirements
  - Based on publically available algorithms
  - Standardized interface (inputs and outputs)





# Implemented Quality Features

- More than 30 features identified and tested on multiple datasets
  - NFIQ
  - Implemented from ISO/IEC TR 29794-4
    - Frequency Domain Analysis
    - Local Clarity Score
    - Orientation Certainty Level
    - Orientation Flow
    - Radial Power Spectrum
    - Ridge Valley Uniformity
  - Gabor filter
  - Ridge line count
  - Gabor (Shen et al., Quality Measures of Fingerprint Images, 2001)
  - Minutiae count in region of interest
  - FingerJetFX



# Feature Example

## Orientation Certainty Level

- See NFIQ 2.0 project page at  
[http://www.nist.gov/itl/iad/ig/development\\_nfiq\\_2.cfm](http://www.nist.gov/itl/iad/ig/development_nfiq_2.cfm)
- ISO/IEC 29794-4:2010
- Block wise approach

OCL input parameters		
Name	Default	Description
$I$	-	Input image
$B_h$	32	Block height in pixels
$B_w$	32	Block width in pixels
$I_{mask}$	-	Segmentation mask

```
function [orientationCertaintyLevel] = compOcl(im, mask
    allfun = inline('all(x(:))');
    [rows cols] = size(im);
    eblksz = ceil(sqrt(sum(v1sz.^2)));
    blkoffset = ceil((eblksz - blksz)/2);
    mapsize = fix(([rows cols] - (eblksz - blksz))./blk
    maskBseg = false(mapsize);

    ocls = zeros(mapsize);

    std::list<NFIQ::QualityFeatureResult> Orient
        const NFIQ::FingerprintImageData & fing
    {
        std::list<NFIQ::QualityFeatureResult> fe
        // check if input image has 500 dpi
        if (fingerprintImage.m_ImageDPI != NFIQ
            throw NFIQ::NFIQException(NFIQ::e

        Mat img;
        try
        {
            // get matrix from fingerprint image
            img = Mat(fingerprintImage.m_ImageH
        }
```



# Orientation Certainty Level

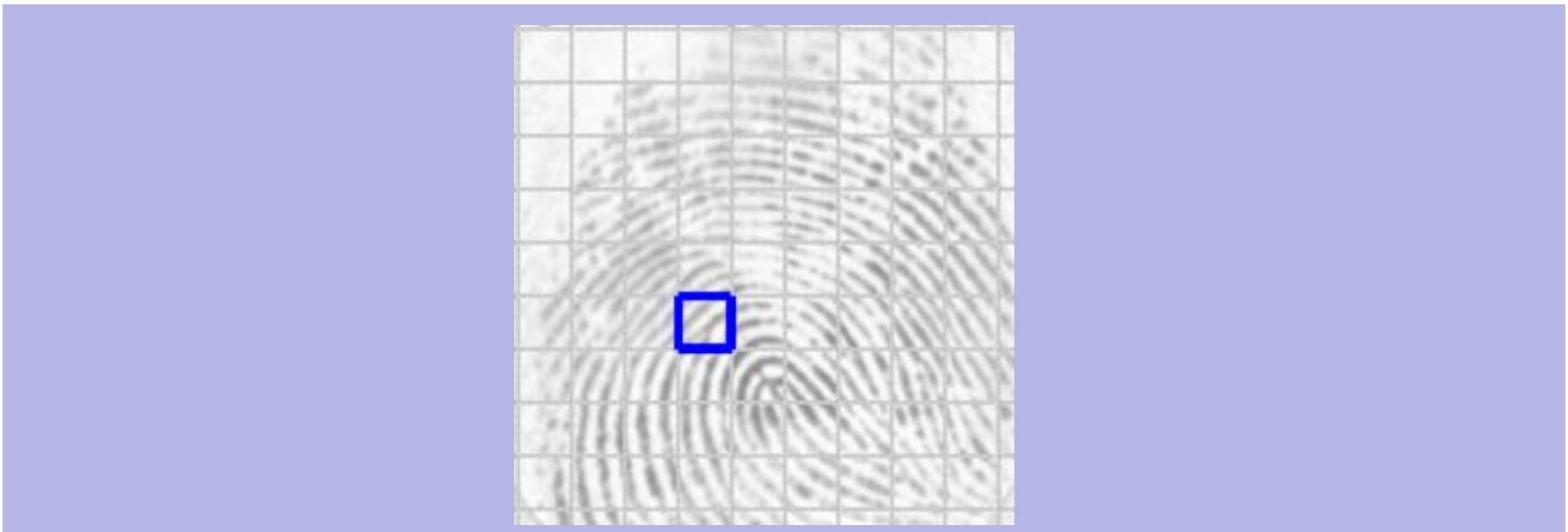
Algorithm → Covariance

1. Compute the intensity gradient of each block

$$[dx \quad dy] = \text{gradient}(B)$$

2. Compute the covariance matrix from the gradients

$$C = \frac{1}{N} \sum_N \left\{ \begin{bmatrix} dx \\ dy \end{bmatrix} \begin{bmatrix} dx & dy \end{bmatrix} \right\} = \begin{bmatrix} a & c \\ c & d \end{bmatrix}$$



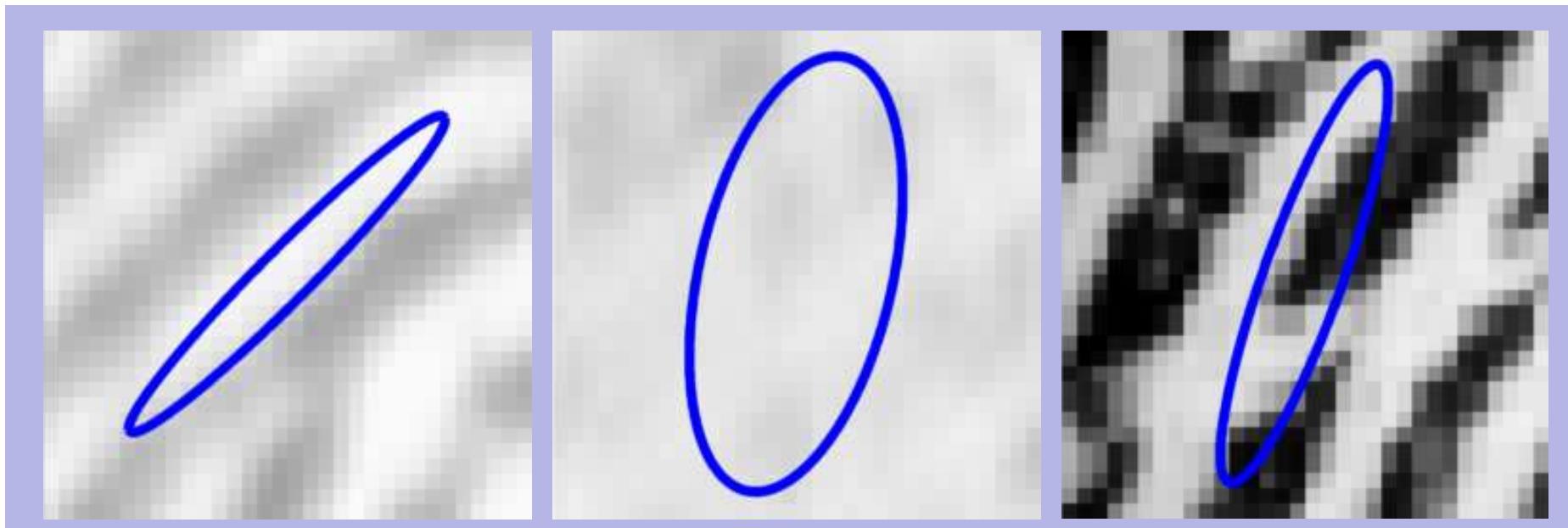
# Orientation Certainty Level

Algorithm → Eigenvalue computation

3. Compute the eigenvalues to obtain *OCL* for each block

$$\lambda_{min} = \frac{a + b - \sqrt{(a - b)^2 + 4c^2}}{2}$$

$$\lambda_{max} = \frac{a + b + \sqrt{(a - b)^2 + 4c^2}}{2}$$

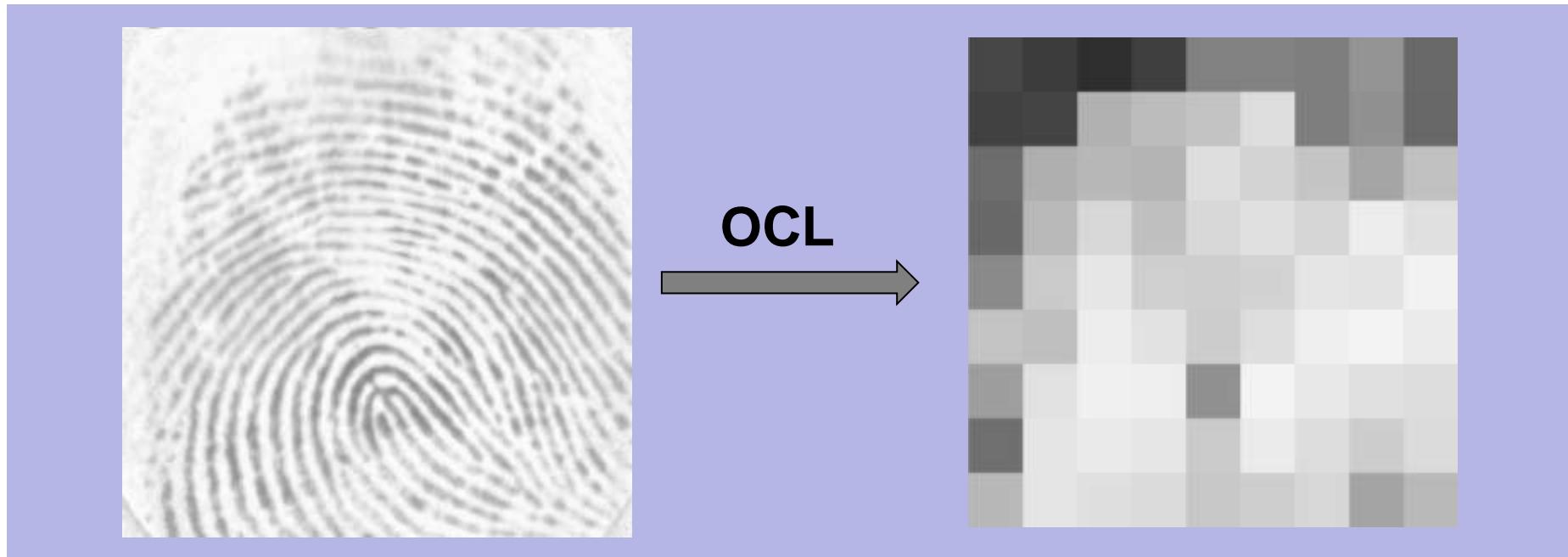


# Orientation Certainty Level

Algorithm → Computing the quality score

- Local orientation certainty level
  - A ratio in the interval [0, 1] where 1 is highest certainty level and 0 is lowest.

$$OCL = 1 - \frac{\lambda_{min}}{\lambda_{max}}$$





# Shaping of Gabor filter according to detected ridge-line frequency

- Feedback from previous workshop at IBPC '12 to use:
  - Dynamic filter bank based on detected ridgeline frequency
  - In progress using ridgeline counting and detected frequency peak



# Actionable Quality

## Providing more than a quality value

- Detectors
  - Centeredness (based on singularity position)
  - Wetness/pressure
  - Completeness
  - Ghostprints
- Motivation:
  - “It would be useful to have a detector for too dry/wet fingers, too low/high pressure, and out-of-center fingerprints.” – Greg Cannon during IBPC ’12 NFIQ 2.0 workshop
  - Reply back then was: “Whether this can be detected or not depends on the training data. Contributions of finger images that are known to have low/high pressure etc. are welcome”.



# Data collection for wet/dry detection

## Overview

- 5 fingerprint sensors (optical)
- 33 subjects
- 4 impressions/finger/sensor
- 6600 images total
- 4 types of treatment
  - No treatment
  - alcohol-dried
  - crème-moisturized
  - water

# Data collection for wet/dry detection

## Examples

- Objective measurement of skin moisture level



62.5%



84.6%



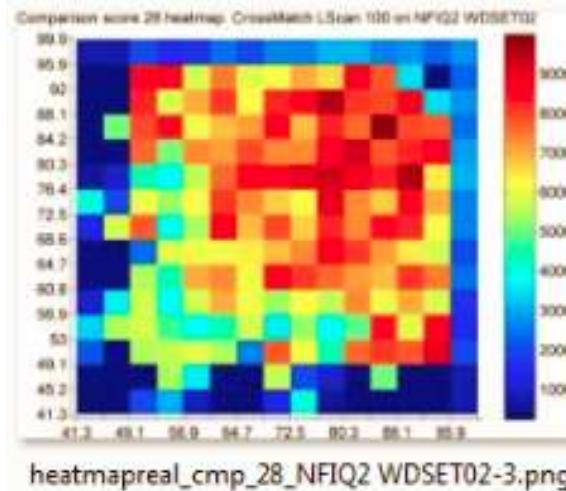
99.9%



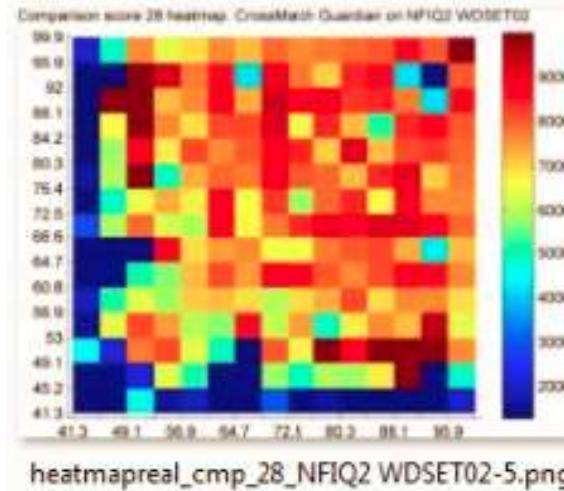
# Observations on wet/dry impressions

- Wet fingerprints are generally handled well by recent sensors
- Dry fingerprints cause degradation in comparison score

Older generation sensor



New generation sensor



See master thesis by Marek Dusio (DTU) – to be published in June 2013



# NFIQ 2.0 Lite

- Motivation:
  - Execution speed of feature extraction is important in some applications (even though processors are getting faster and faster). Aim at 125–150 ms for inclusion of quality assessment into auto-capture loop of sensors. – IBPC ‘12
- Potential solution:
  - Pre-compute a lookup table which can speed up the quality assessment

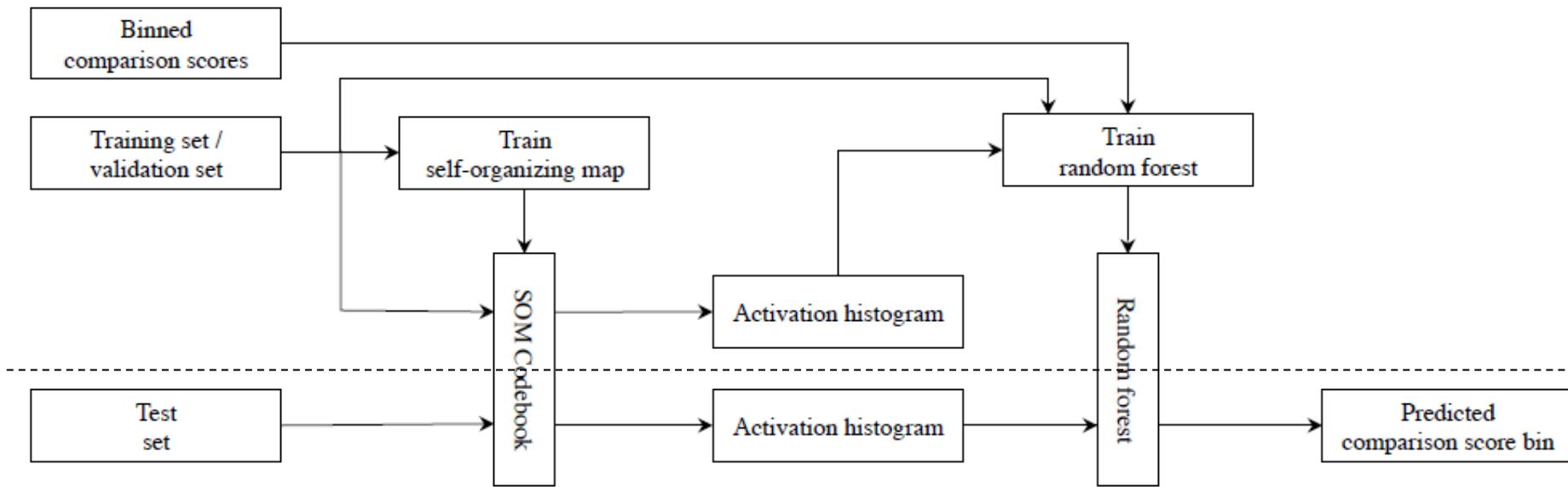
# NFIQ 2.0 Lite

## Machine Learning approach



- Two stage process
  - Clustering using Self-Organizing Map
  - Prediction using Random Forest

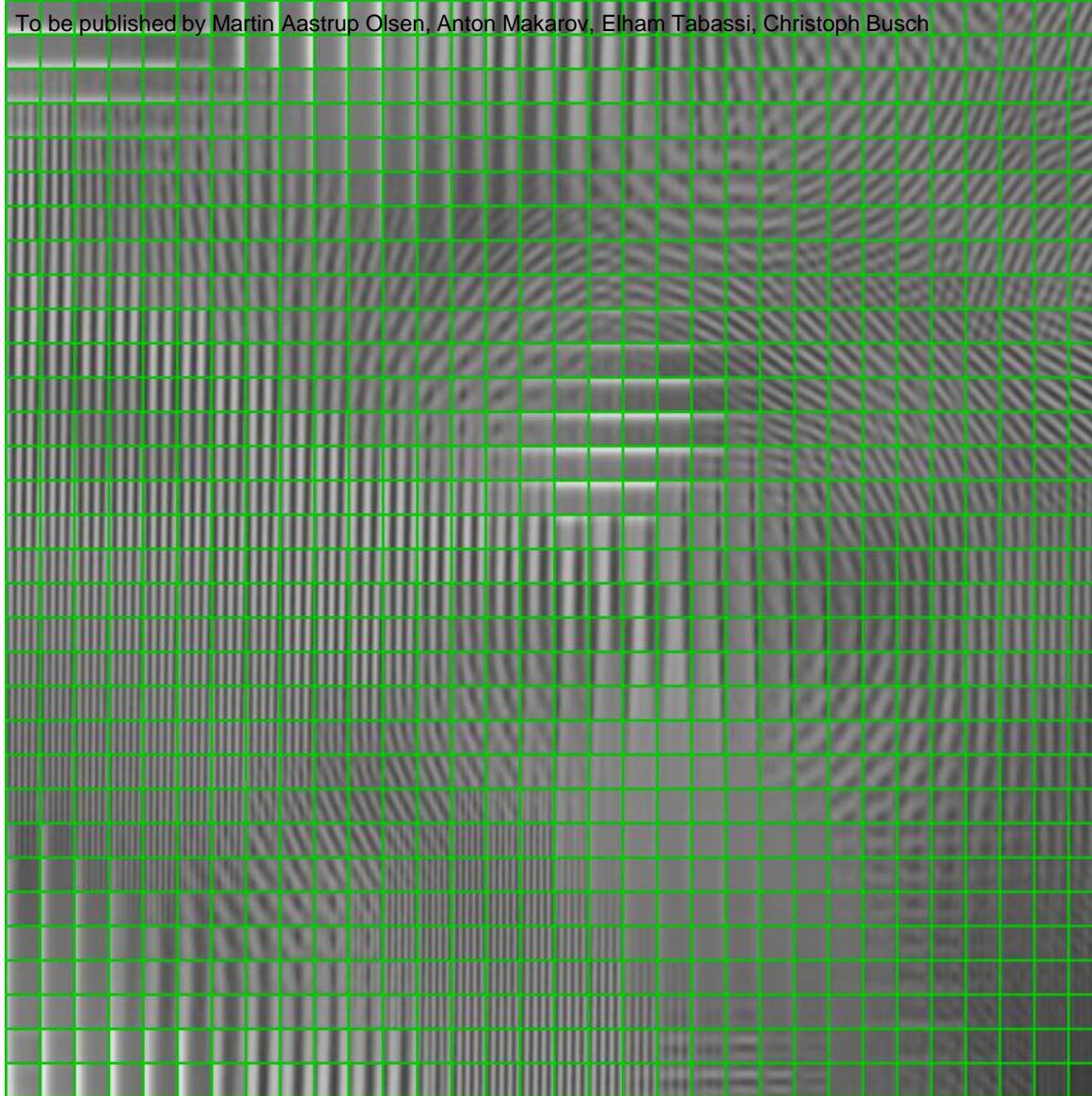
To be published by Martin Aastrup Olsen, Anton Makarov, Elham Tabassi, Christoph Busch



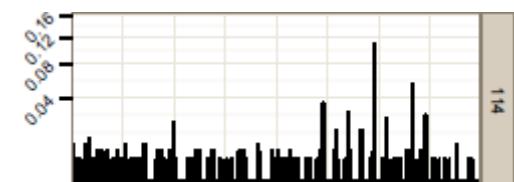
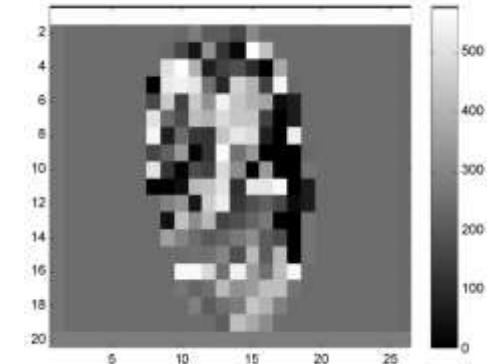
# SOM example



To be published by Martin Aastrup Olsen, Anton Makarov, Elham Tabassi, Christoph Busch

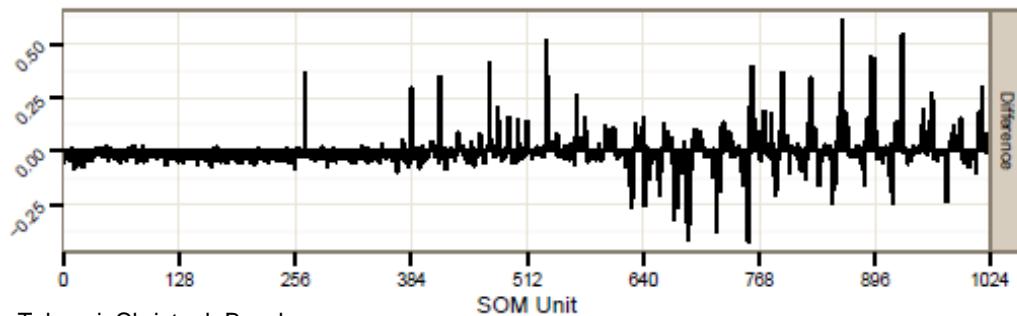
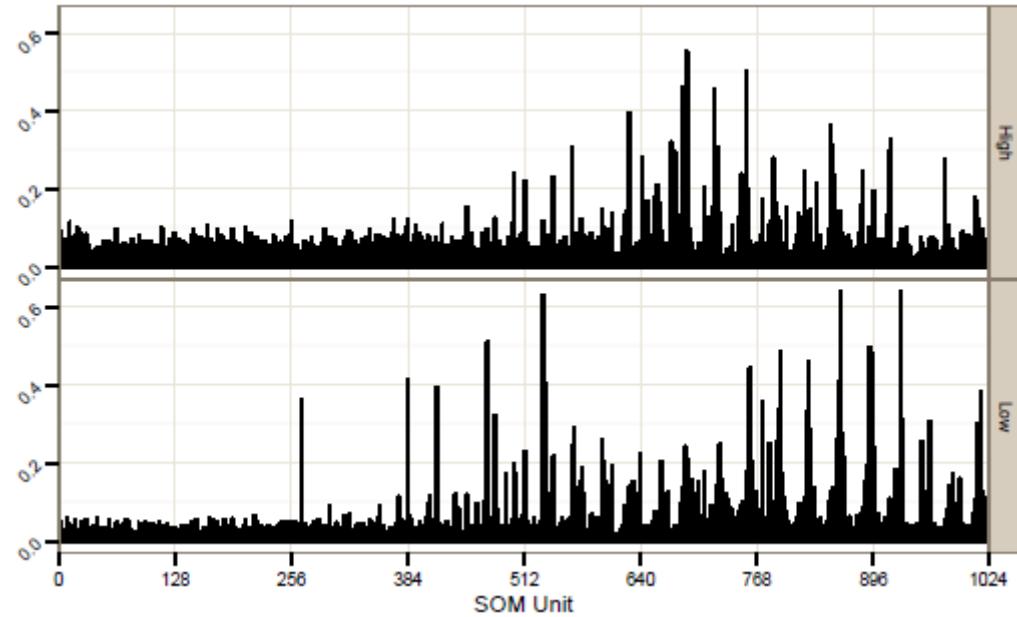


Blocksize: 24 x 24 px  
SOM units: 32 x 32



# SOM activation histogram

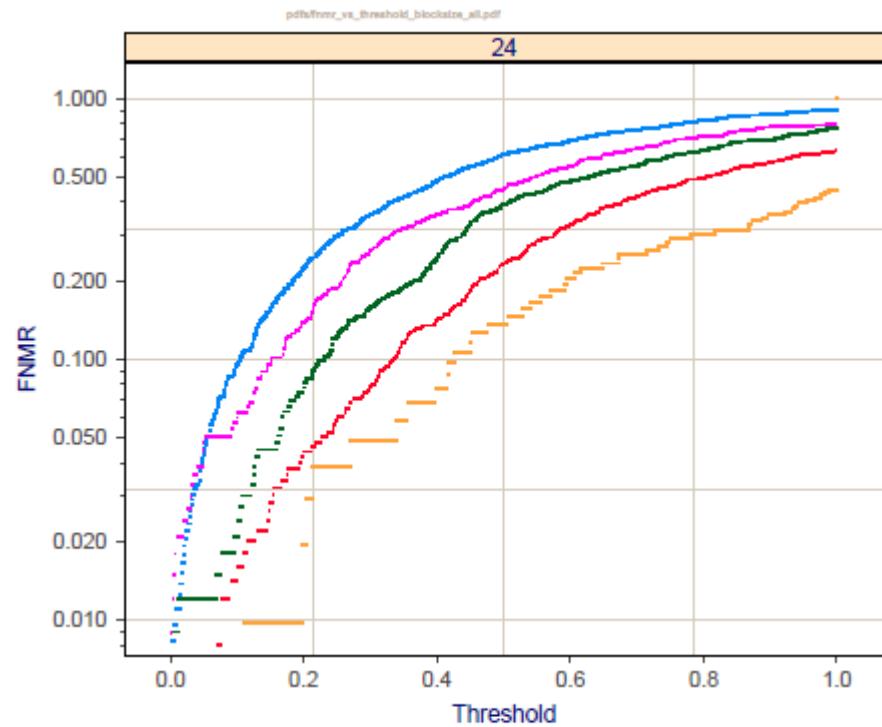
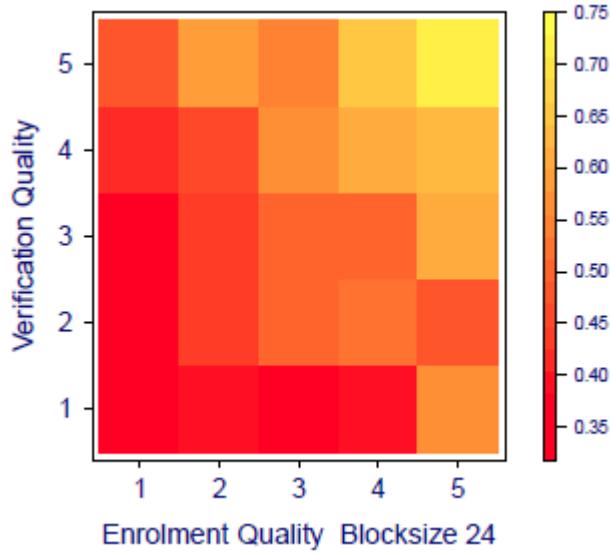
- 64 images with highest comparison score
- 64 images producing false non-match at  $\text{FNMR} = 10^{-4}$
- Difference between histograms.



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# Performance indication

- FNMR vs. score threshold for each level of quality





# Contact

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